US006548895B1

(12) **United States Patent**
Benavides et al.

(10) **Patent No.: US 6,548,895 B1**
(45) **Date of Patent: *Apr. 15, 2003**

(54) **PACKAGING OF ELECTRO-MICROFLUIDIC DEVICES**

(75) Inventors: **Gilbert L. Benavides**, Albuquerque, NM (US); **Paul C. Galambos**, Albuquerque, NM (US); **John A. Emerson**, Albuquerque, NM (US); **Kenneth A. Peterson**, Albuquerque, NM (US); **Rachel K. Giunta**, Albuquerque, NM (US); **David Lee Zamora**, Albuquerque, NM (US); **Robert D. Watson**, Tijeras, NM (US)

(73) Assignee: **Sandia Corporation**, Albuquerque, NM (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 3 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/790,305**

(22) Filed: **Feb. 21, 2001**

(51) **Int. Cl.**[7] **H01L 23/48**; H01L 23/10; H01L 23/34; F16K 25/00; F16K 51/00

(52) **U.S. Cl.** **257/712**; 137/594; 137/597; 257/714; 257/706; 257/713; 257/734; 257/784; 257/782; 257/787

(58) **Field of Search** 137/454, 594, 137/597, 454.2, 596; 257/712, 713, 706, 784, 734, 782, 787

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,640,995	A	6/1997	Packard et al.	137/597
5,964,239	A	10/1999	Loux et al.	137/15
6,136,212	A	10/2000	Mastrangelo et al.	216/49
6,443,179	B1 *	9/2002	Benavides et al.	137/454.2

OTHER PUBLICATIONS

Co–pending US patent application "Packaging of Electro–Microfluidic Devices", G. Benavides, et al, commonly assigned to Sandia Corporation, Albuquerque, New Mexico, Docket No. SD–6729.

T. Merkel, M. Graeber and L. Pagel, "A new technology for fluidic microsystems based on PCB technology", Sensors and Actuators 77 (1999) pp. 98–105.

C. Cotofana, A. Bossche, P. Kaldenberg, J. Mollinger, "Low–cost plastic sensor packaging using the open–window package concept", Sensors and Actuators A 67 (1998) pp. 185–190.

E. T. Enikov and J. G. Boyd, "Electroplated electro–fluidic interconnects for chemical sensors," Sensors and Actuators 84 (2000) pp. 161–164.

P. Galambos and G. Benavides, "Electrical and Fluidic Packaging of Surface Micromachined Electro–Microfluidic Devices," Microfluidic Devices and Systems III, Proceedings of SPIE—The International Society of Optical Engineering, vol. 4177, 2000, pp. 200–207.

(List continued on next page.)

Primary Examiner—Tom Thomas
Assistant Examiner—Nitin Parekh
(74) *Attorney, Agent, or Firm*—Robert D. Watson

(57) **ABSTRACT**

A new architecture for packaging surface micromachined electro-microfluidic devices is presented. This architecture relies on two scales of packaging to bring fluid to the device scale (picoliters) from the macro-scale (microliters). The architecture emulates and utilizes electronics packaging technology. The larger package consists of a circuit board with embedded fluidic channels and standard fluidic connectors (e.g. Fluidic Printed Wiring Board). The embedded channels connect to the smaller package, an Electro-Microfluidic Dual-Inline-Package (EMDIP) that takes fluid to the microfluidic integrated circuit (MIC). The fluidic connection is made to the back of the MIC through Bosch-etched holes that take fluid to surface micromachined channels on the front of the MIC. Electrical connection is made to bond pads on the front of the MIC.

32 Claims, 33 Drawing Sheets